

IN THE FIGURES:

Please replace original Figs. 1, 2 and 3 with the attached best available copies of the figures (pictomicrographs) as replacement sheets.

REMARKS

Status of the Claims

The Examiner has withdrawn the Restriction Requirement, under which Applicants were asked to elect between process and product by process claims.

Applicants however now consider that, since process claims and product-by-process claims are directed to the same invention, process claims 11-22 provide adequate protection for the present invention. To expedite allowance, Applicants cancel product-by-process claims 23-25.

New claims 26 and 27 find support in paragraph [00019] of the published specification.

Claims 11-22 are under examination.

Drawings

New corrected drawings in compliance with 37 CFR 1.121(d) are required in this application because of the poor drawing quality of Figs. 1 and 3.

In response, Applicants submit herewith the best available copies of Figs. 1-3. The quality is the same as the quality of the figures found in the priority document and the WO application. Applicants advise that the drawings are pictomicrographs, and as such can not be improved or redrawn by a draftsman.

Accordingly, acceptance of the attached revised figures is respectfully requested.

Claim Objections

Claim 15 is objected to because of the following informalities: "600-700 C" should be amended to be "600-700°C". Appropriate correction is required.

Claim 15 has been corrected.

Claim Rejections - 35 U.S.C. § 112

Claims 14-15 are rejected under 35 U.S.C. §112, second paragraph.

There is insufficient antecedent basis for the limitation "the material". in claim 14.

In response, claim 14 has been amended to refer to the drop forged part.

Claim 15 recites the limitation "the relaxation thermal treatment". There is insufficient antecedent base.

In response, claim 15 has been amended.

Claim Rejections - 35 U.S.C. § 102/103

Claims 23 and 25 are rejected under 35 U.S.C. §102(b) as anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over Serfozo et al. (US 4,055,975).

Claims 23-25 are also rejected under 35 U.S.C. §102(b) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Kusano et al. (US 6,077,369).

The Examiner notes that these claims are directed to a product, and not a process.

The rejection is rendered moot by the cancellation of these claims.

Claim Rejections - 35 U.S.C. § 103

Claim 11 is rejected under 35 U.S.C. §103(a) as being unpatentable over Serfozo et al. (US 4,055,975).

In regards to claim 11, Serfozo et al. ('975) discloses forging a Ti-6Al-4V alloy while at a temperature of approximately 1200°F -1950°F (col. 3, lines 1-62), which overlaps the temperature range of the instant invention, and cooling (col. 7, lines 1-10).

Applicants respectfully traverse.

The present invention addresses the problem that titanium, in particular, while having advantageous properties such as being almost 50% lighter than steel, exhibits disadvantageous properties, and in particular a comparatively low modulus of elasticity. Drop forged moving titanium parts of motors, such as, for example, connecting rods, crankshafts, camshafts and/or valve parts, can as a result tolerate only low loads.

The present invention provides a process for production of drop forge parts in which a higher E-modulus of the drop forge parts is achieved. The cited prior art does not teach any such process, nor the critical limitations of the present process claims, as discussed below.

The present invention is achieved by a process controlled to within specified critical temperature limitations such that in the alloy, during forming, the α -low temperature phase is

replaced by the β -high temperature phase in such a manner that an α / β microstructure, or as the case may be, an inventive composite, is produced (Fig. 1), which combines the high strength characteristics of the β phase with the higher E-modulus of the α phase. This temperature-dependent deformation range is to be selected very narrowly, or as the case may be, heating or deformation temperatures are to be within the range of 5-15 °C above the α / β phase boundary. Departing from this range, then either isolated α or β phases exists in a β or, as the case may be, α base matrix (Fig. 2)(in the so-called high temperature deformation, more β -phases are produced and in the low temperature deformation, more α -phases are produced), so that disadvantageously the low E-modulus of the β phase results.

Accordingly, the alloys, during deformation, are heated specifically to 5-15°K above the α / β phase boundary (transition temperature) and subsequently are cooled to form α / β – Ti-alloys or, as the case may be, α / β – Ti containing materials which have both a high strength, cubic space-centered β -phase as well as hexagonal α -phase with high E-modulus.

Further, as claimed in claim 15, after the deformation, a relaxation treatment can follow at $650 \pm 50^\circ\text{C}$ in order to achieve, besides the reduction of undesired deformation tensions, a stronger intermixing of the α / β microstructure with the α -phase with high E-modulus (Fig. 3). Thereby, the heating time is to be limited in such a manner that the α / β microstructure is not destroyed.

Finally, as claimed in claim 22, the desired α / β microstructure or grain structure can be improved inventively with respect to a stronger interlacing of the α and β phases, in that after the deformation, it is slowly cooled in air or, as the case may be, in a gas atmosphere. Thereby the α / β microstructure is further interfused by the α -phase. As a result, an alternating of the arrangement of the α phase and the β phase in the material is achieved. Basically, a mixed phase in an α / β web structure is obtained.

With these Ti connecting rods drop forged at $975^\circ\text{C} \pm 5^\circ\text{C}$, which after the deformation are slowly cooled in air, there can be achieved in an α / β alloy Ti Al 6 V with an E-modulus of 130 GPa or, as the case may be, a Ti Al 6 Fe2 Si an E-modulus of 140 GPa (claims 26 and 27). A subsequent relaxation heating at 650°C (claim 15) brings about an additional E-modulus increase of at least 5 GPa. The break elongation achieved by the inventive process lies, in the case of alloys, (for example, Ti Al 6 V 4 Ti Al 6 Fe2 Si) at above 1,100 MPa or, as the case may be, the technical elastic limit lies above 1,000 MPa.

In order for Serfozo to render the present invention obvious, it would be necessary for Serfozo to teach the claimed deliberate manipulative steps, within the claimed critical temperature limitations.

It is well settled that manipulation of a parameter which had not previously been recognized or appreciated as being a result effective parameter may be the basis for patentability. *Ex parte Viscardi*, 136 USPQ 382. Viscardi discovered that addition of carbon dioxide will remove static electricity from a printing press. The Examiner rejected apparatus and method claims over a reference which taught addition of carbon dioxide to a printing press, but for a different reason. The court held that there is merit in the contention that a reference patent does, as urged by the Examiner, inherently provide carbon dioxide which will remove static electricity. However, in an absence of appreciation by patentee Catlin (the cited reference) of the fact that carbon dioxide will remove static electricity, there is no reason why he, or one skilled in the art following his teaching, should inherently adjust the concentration of carbon dioxide for removal of complete static charge; hence, manipulative steps of applicant's claims do not inherently result from reference's disclosure.

Here, similarly, Serfozo et al do not appreciate the present underlying principles, nor teach the deliberate manipulative steps necessary to, achieve high modulus of elasticity in a forged part.

Serfozo et al merely teach a process of precision forging of titanium or a titanium alloy in which the forging stock and a segmented die are first heated to forging temperature while separated, and are then assembled together and heated again to that temperature, with the stock being covered by a protective coating preferably containing glass grit, and the die sections being coated with lubricant. The heated die and contained heated forging stock are then inserted in a heated holder and the stock subjected to forging force, to partially but not completely deform the stock to the shape of the die cavity, following which the die and stock are separated and the stock allowed to cool, flashing is removed from the stock, the die is cleaned, the die and stock are recoated and then reheated separately and then together, and the stock is forged again to assume more closely the shape of the die cavity. The series of recoating, heating and forging steps are performed at least twice, and may be repeated one or more additional times as necessary to completely forge the part to the die cavity shape.

Since each successive heating step alters any grain structure formed in earlier heating steps, it is the last heating step that determines the final grain structure.

Serfozo et al col. 3, lines 63-66 teach that the optimal forging temperature of Ti Al 6 V 4 is 1700-1750°F (926-954°C).

In the present invention, in contrast, when the titanium alloy is Ti Al 6 V 4, the heating is to a temperature of 975°C - 990°C.

Thus, Serfozo et al do not teach the present critical temperature ranges and process steps, in particular, heating the Ti alloy within the range of 5-15 °C above the α / β phase boundary during deforming to form β phases and to subsequently cool the Ti alloy.

Accordingly, Serfozo et al do not teach the present invention

Accordingly, withdrawal of the rejection is respectfully requested.

Next, claims 12-13 and 24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Serfozo et al. (US 4,055,975) as applied to claims 11 and 23 above, and further in view of Adams et al. (US 5,342,458).

In regards to claim 12, the Examiner asserts that a connecting rod would be a moving part in a motor.

In regards to claims 13 and 24, Serfozo et al. ('975) discloses a Ti-6Al-4V alloy rod as described above, but Serfozo et al. ('975) does not specify that the rod would be used as a connecting rod.

Adams et al. ('458) discloses using the Ti-6Al-4V alloy as a connecting rod in automotive applications in order to increase fuel efficiency and correspondingly lower the operating costs of motor vehicles (col. 1, lines 16-39).

In response, Applicants point out that neither Serfozo et al nor the secondary references teach the critical temperature limitations and process steps of claim 11, thus, no combination with a secondary reference teaching types of parts will reach the present invention as defined in the dependent claims.

Claims 11-17 and 19-22 are rejected under 35 U.S.C. 103(a) as being obvious over Kusano et al. (US 6,077,369).

In regards to claim 11-15, Kusano et al. ('369) discloses processing a Ti-6Al-4V alloy used for engine valves, which would be a moving part of a motor, wherein the alloy would be

forged; hot straightened at a temperature in the range of 600-1000°C, which overlaps the range of heating within the range of 5-15°C above the α / β phase boundary; annealed for 1 hour (60 minutes) at a temperature in the range of 600-1000°C, which overlaps the temperature range of the instant invention (Example 4). Kusano et al. ('369) further discloses cooling the rod while applying a tension after straightening (claim 3).

With respect to the recitation "to form β phases" as recited in line 4 of claim 11, the Examiner notes that Kusano et al. ('369) discloses processing the alloy in the same or a substantially similar manner. Therefore, the formation of β phases would be expected. MPEP 2112.01 I.

In response, Applicants repeat that the present invention is only achieved by a process controlled to within very narrow, specified critical temperature limitations such that in the alloy, during forming, the α -low temperature phase is replaced by the β -high temperature phase in such a manner that an α / β microstructure, or as the case may be, an inventive composite, is produced which combines the high strength characteristics of the β phase with the higher E-modulus of the α phase. This temperature-dependent deformation range is to be selected very narrowly. Kusano et al. teaching to heating to a temperature in the range of 600-1000°C will not lead anyone of ordinary skill to the present invention.

Next, claim 18 (5-15 wt. % Zr and/or Hf) is rejected under 35 U.S.C. 103(a) as being obvious over Serfozo et al. (US 4,055,975) or Kusano et al. (US 6,077,369) with evidence from the ASM Handbook Volume 2.

In regards to claim 18, Serfozo et al. ('975) or Kusano et al. ('369) disclose the processing of Ti-6Al-4V alloys as described above, but Serfozo et al. ('975) and Kusano et al. ('369) are silent with regard to the presence of hafnium in the alloys.

The ASM Handbook Volume 2 discloses that hafnium would be present in titanium at a level of 0.25 ppm (pg. 1096, Table 2).

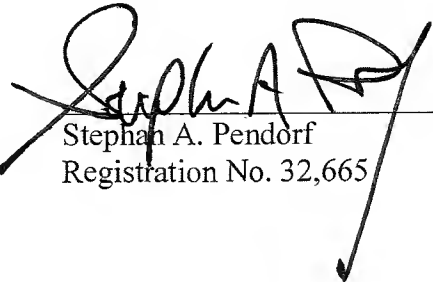
In response, Applicants submit that ASM Handbook Volume 2 (pg. 1096, Table 2) teaching that hafnium would be present at impurity levels in an amount of 0.25 ppm is far from and does not render obvious the claimed range of 5-15 wt. %.

Accordingly, withdrawal of the rejection is respectfully requested.

The Commissioner is hereby authorized to charge any fees which may be required at any time during the prosecution of this application without specific authorization, or credit any overpayment, to Deposit Account Number 16-0877.

Should further issues remain prior to allowance, the Examiner is respectfully requested to contact the undersigned at the indicated telephone number.

Respectfully submitted,



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